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Description

The present invention relates to a method of manufacturing a reflective type liquid crystal display device.

Recent years have seen a rapid progress of display devices. Of the display devices hitherto known, a liquid crystal display device is advantageous in several respects. Firstly, it consumes little electric power. Secondly, it is thin. Thirdly, it has a long life. Very recently, television sets have been made using liquid crystal displays.

Most liquid crystal television sets use a so-called Guest-Host type liquid crystal, a mixture of nematic liquid crystal and dichroic dye. This is because the Guest-Host type liquid crystal consumes little electric power and has a large field angle. If a reflective type display device using Guest-Host type liquid crystal is to present a picture with high contrast, it must have a reflective film with a white, light scattering surface. Hitherto, such a reflective film has been white metal film with small depressions, e.g. an aluminum film with small depressions. A few methods of forming such a white metal film are disclosed in Japanese Patent Disclosure JP—A—55-9517.

They are:

(1) To sputter and deposit metal in an atmosphere under regulated conditions, e.g., temperature.

(2) To etch a white metal film, thus roughening the surface of the film.

(3) To roughen the surface of a white metal film by shot blasting.

These methods are disadvantageous. In any of these methods, small protrusions or depressions are formed directly on the surface of the reflective film. The edges of the protrusions or depressions thus formed inevitably have an acute angle. Light applied on the edge of each protrusion or depression will undergo multiple reflection and a portion of the light will be absorbed into the reflective film. Consequently, the reflective film will present a dark image.

GB—A—2 064 805 discloses a method for manufacturing a reflective type liquid crystal display device comprising roughening the surface of a plastic substrate, heat treating the roughened surface to eliminate sharp points, and depositing a reflecting metal on the roughened surface. The roughening step is carried out by grinding, sand blasting or moulding.

It is an object of the invention to provide a method of manufacturing of a reflective type liquid crystal display device which avoids the drawbacks described above and which displays bright images with high contrast.

According to the invention, there is provided a method for manufacturing a reflective type liquid crystal display device, comprising the steps of:

forming a projection pattern on a substrate by selective etching using a mask pattern;

forming a polymer resin layer on the projection pattern, such that said polymer resin layer has small protrusions and depressions in the surface facing away from the substrate, said protrusions and depressions having a gently curved profile and conforming with the projection pattern and;

forming a reflective metal film on the polymer resin layer, such that the said reflective metal film has small protrusions and depressions in its outer surface, said protrusions and depressions having a gently curved profile conforming with the said surface profile of the polymer resin layer to produce a reflective part of the reflective type liquid crystal display device.

Light applied on any portion of the reflective metal film does not undergo multiple reflection and is not absorbed into the reflective metal film. Light incident on the liquid crystal display device of this invention is reflected from the reflective metal film to such a degree as is determined by the reflectivity of the metal forming the reflective film. The liquid crystal display device can therefore emit white scattered light and can thus display a very bright picture.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:—

Fig. 1 is a sectional view of a liquid crystal display device, which is not in accordance with the invention but shows the general appearance of a liquid crystal display device;

Fig. 2 is a sectional view of the reflective part of a liquid crystal display device manufactured according to the invention;

Figs. 3A to 3C are sectional views illustrating how to manufacture the reflective part shown in Fig. 2;

Fig. 4 is a sectional view of the device having the reflective part shown in Fig. 2;

Fig. 5 is a sectional view of another liquid crystal display device having a reflective part similar to the part shown in Fig. 2;

Fig. 6 is a sectional view of still another liquid crystal display device having a reflective part similar to the part shown in Fig. 2; and

Figs. 7A and 7B are sectional views of two projection patterns each formed on a substrate having a rough surface.

As shown in Fig. 1, a liquid crystal display device comprises a semiconductor substrate 1 and a metal wiring layer 2 formed on the substrate 1. The metal wiring layer 2 electrically connects elements (not shown) formed in the substrate 1 for driving the display device, such as transistors, resistors or capacitors. A polyimide resin layer 3 is coated on the semiconductor substrate 1. A display electrode 4 of aluminum, or a reflective film, is formed on the polyimide resin layer 3. The polyimide resin layer has an upper surface with small protrusions or depressions having a gently curved profile, and the display electrode 4 has an upper surface with small protrusions or depressions having a gently curved profile. The upper surface of the display electrode 4 therefore makes a white scattered surface. The device further comprises a transparent glass sub-

strate 6 and a transparent conductive film 5 formed on the transparent substrate 6. A Guest-House type liquid crystal 7 is filled in a gap between the display electrode 4 and the transparent conductive film 5.

A silver film may be used in place of the aluminum film.

Fig. 2 shows the reflective part of the liquid crystal display device manufactured according to the invention. This reflective part comprises a substrate 11, a projection pattern 12 formed on the substrate 11, a polymer resin layer 13 formed on the substrate 11 and the projection pattern 12, and a reflective metal film 14 formed on the polymer resin layer 13. The layer 13 is made of polyimide resin or the like. The metal film 14 has a high reflectivity. The metal film 14 of the reflective part of this structure has a uniformly white scattered surface.

With reference to Figs. 3A to 3C, it will now be described how the reflective part shown in Fig. 2 was manufactured.

Firstly, as shown in Fig. 3A, a layer 21 made of insulating material, semiconductor material or metal, or consisting of two or more layers made of insulating material, semiconductor material or metal was formed on a substrate 11. The layer 21 was then selectively etched, using a mask pattern 22, thus forming a projection pattern 12 as shown in Fig. 3B.

The layer 21 may be formed by CVD, sputtering deposition, evaporation or spinner coating. To form the projection pattern 12, a method other than selective etching may be used. For example, a plating method of lift-off method may be employed.

The projection pattern 12 consists of a number of spot layers. Generally it is desired that the spot layers should be circular and should be arranged as densely as possible. Preferably, the spot layers should be arranged at a pitch of 1 to 50 µm and should be 0.1 to 10 µm thick. Alternatively, the projection pattern 12 may be a perforated layer having a number of circular openings.

If the layer 21 is selectively etched by anisotropic etching such as reactive ion etching, it can be made into a highly precise projection pattern 12. If reactive ion etching is conductive on the layer 21, using a proper etchant gas under proper pressure, a projection pattern will be formed which has inclined sides.

After the projection pattern 12 had been formed as described above, the mask pattern 22 was removed. Polymer resin such as polyimide resin having a predetermined viscosity was coated on the substrate 11 and the projection pattern 12 as shown in Fig. 3C, thereby forming a polymer resin layer 13.

The polymer resin may be coated by spin coating or vibration coating. If spin coating is used, the substrate 11 may be rotated by a spinner at, for example, 2000 to 5000 rpm. The spinning speed and the viscosity of the polymer resin may be changed to thereby form a polymer resin layer 13 having a desired profile.

Upon completion of the polymer resin layer 13, a metal layer 14 of a high reflectivity is formed on the polymer resin layer 13. The metal layer 14 may be made of aluminum, silver or an alloy thereof and may consist of two or more layers which are vapor-deposited one upon another. If the metal layer 14 has a multi-layer structure, the uppermost layer must have the highest reflectivity of all the layers.

The polymer resin layer had small protrusions or depressions having a gently curved profile over its entire surface. The edges of the protrusions or depressions of the metal layer 14 vapor-deposited on the polymer resin layer 13 have a gentle angle. Light applied on the metal layer 14 did not undergo multiple reflection.

The structure shown in Fig. 2 (hereinafter called the "reflective part") may be used to form such a liquid crystal display device as illustrated in Fig. 4.

In the liquid crystal display device of Fig. 4, the reflective part is used as a reflective plate. The device comprises a first glass substrate 44a, a plurality of transparent electrodes 42 arranged on the substrate 44a, a second glass substrate 44b, a transparent electrode 43 formed on the substrate 44b and a liquid crystal 41 filled in a gap between the first substrate 44a and the second substrate 44b. A reflective plate 45 which comprises a substrate and reflective film 14 formed on the entire surface of the substrate is positioned in the light path of the liquid crystal layer 41. The plate 45 corresponds to the reflective part shown in Fig. 2, though neither the projection pattern 12 nor the polymer resin layer 13 is shown in Fig. 4.

Fig. 5 shows another liquid crystal display device having a reflective part similar to the part shown in Fig. 2. This device comprises a liquid crystal 41 filled in a gap between a transparent electrode 43 formed on a glass substrate 44 and another glass substrate 51. Metal strips or islands 52 are formed on the glass substrate 51. These metal strips or islands 14 function as both the reflective film and display electrodes.

Fig. 6 illustrates a liquid crystal display device of an active matrix system which is formed on a semiconductor substrate 61 made of single-crystalline silicon. More specifically, switch/capacitor arrays of liquid crystal driving elements consisting of MOSFETs 62 and MOS capacitors (only one of the MOSFETs and only one of the MOS capacitors being shown) are integrated on the substrate 61. The array is covered with a polymer resin layer 64. Metal films 65 are formed on the polymer resin layer 64. Each of the metal films 65 functions as both a reflective film and a display electrode. The metal films 65 shown in Fig. 6 is electrically connected to the MOS capacitor 63 in a contact hole 69 cut in the polymer resin layer 64. A liquid crystal 41 is filled in a gap between the metal films 65 and a transparent electrode 66 formed on a glass substrate 67. The single-crystalline silicon substrate 61 may be replaced by an SOS substrate or a glass plate with a TFT film formed on it.

In order to form a metal reflective film with

small protrusions or depressions having a gently curved profile using a projection pattern, the projection pattern may be formed on a flattening layer 71 formed on the rough surface of a substrate 72 as illustrated in Fig. 7A. In this case, a projection pattern 12 is formed on the flattening layer 71 which has a flat, smooth surface. Alternatively, a projection pattern may be formed by patterning the surface region of the flattening layer 71 as illustrated in Fig. 7B. Further, a projection pattern may be formed by patterning the surface region of the substrate 72.

Claims

1. A method for manufacturing a reflective type liquid crystal display device, comprising the steps of:

forming a projection pattern (12) on a substrate (11) by selective etching using a mask pattern (22);

forming a polymer resin layer (13) on the projection pattern (12), such that said polymer resin layer (13) has small protrusions and depressions in the surface facing away from the substrate, said protrusions and depressions having a gently curved profile and conforming with the projection pattern (12) and:

forming a reflective metal film (14) on the polymer resin layer (13), such that the said reflective metal film (14) has small protrusions and depressions in its outer surface, said protrusions and depressions having a gently curved profile conforming with the said surface profile of the polymer resin layer (13) to produce a reflective part of the reflective type liquid crystal display device.

2. A method according to claim 1, characterised in that said polymer resin layer (13) is of thermosetting resin.

3. A method according to claim 2, characterised in that said thermosetting resin is polyimide resin.

4. A method according to claim 1, characterised in that said polymer resin layer (13) is of thermoplastic resin.

5. A method according to claim 4, characterised in that said thermoplastic resin is silicone resin or fluorocarbon resin.

6. A method according to claim 1, characterised in that said reflective metal film (14) is of a metal which is aluminum, aluminum alloy or silver.

7. A method according to claim 1, characterised in that said substrate (72) has an uneven surface, a flattening layer (71) is formed on the uneven surface of said substrate (71), the projection pattern (12) is formed on the flattening layer (71), and the protrusions and depressions of said polymer resin layer conform to the projection pattern (12).

8. A method according to claim 1, characterised in that said liquid crystal is a Guest-Host type liquid crystal.

9. A method according to claim 1, characterised in that said selective etching is performed until the surface of the substrate (11) is exposed.

10. A method according to claim 1, characterised in that said selective etching is performed by reactive ion etching.

11. A method according to claim 1, characterised in that said polymer resin layer (13) is formed by spin coating.

Revendications

1. Procédé de fabrication d'un dispositif d'affichage à cristaux liquides du type réfléchissant, comprenant les opérations suivantes:

former une configuration (12) de parties saillantes sur un substrat (11) par incision sélective à l'aide d'une configuration de masquage (22);

former une couche (13) de résine polymère sur la configuration de parties saillantes (12), de façon que ladite couche de résine polymère (13) présente de petites parties saillantes ou de petits creux dans la surface opposée au substrat, lesdites parties saillantes et lesdits creux ayant un profil régulièrement incurvé et se conformant à la configuration de parties saillantes (12); et

former une pellicule métallique réfléchissante (14) sur la couche de résine polymère (13), de façon que ladite pellicule métallique réfléchissante (14) présente des petites parties saillantes et des petits creux dans sa surface extérieure, lesdites parties saillantes et lesdits creux ayant un profil régulièrement incurvé se conformant audit profil de surface de la couche de résine polymère (13) afin de produire une partie réfléchissante du dispositif d'affichage à cristaux liquides de type réfléchissant.

2. Procédé selon la revendication 1, caractérisé en ce que ladite couche de résine polymère (13) est faite de résine thermodurcissable.

3. Procédé selon la revendication 2, caractérisé en ce que ladite résine thermodurcissable est une résine de polyimide.

4. Procédé selon la revendication 1, caractérisé en ce que ladite couche de résine polymère (13) est faite de résine thermoplastique.

5. Procédé selon la revendication 4, caractérisé en ce que ladite résine thermoplastique est une résine de silicone ou une résine de carbone fluoré.

6. Procédé selon la revendication 1, caractérisé en ce que ladite pellicule métallique réfléchissante (14) est faite d'un métal qui est l'aluminium, un alliage d'aluminium, ou l'argent.

7. Procédé selon la revendication 1, caractérisé en ce que ledit substrat (72) possède une surface non uniforme, on forme une couche (71) de redressement de non-planéité sur la surface non uniforme dudit substrat (71), on forme la configuration de parties saillantes (12) sur la couche de redressement (71), et les parties saillantes et les creux de ladite couche de résine polymére se conforment à la configuration de partie saillante (12).

8. Procédé selon la revendication 1, caractérisé en ce que ledit cristal liquide est un cristal liquide du type hôte accueilli-hôte accueillant.

9. Procédé selon la revendication 1, caractérisé

en ce que l'on effectue ladite incision sélective jusqu'à ce que la surface du substrat (11) soit exposée.

10. Procédé selon la revendication 1, caractérisé en ce qu'on effectue ladite incision sélective par incision ionique réactive.

11. Procédé selon la revendication 1, caractérisé en ce qu'on forme la couche de résine polymère (13) par enduction rotative.

Patentansprüche

1. Verfahren zur Herstellung einer Reflexions-Flüssigkristallanzeigevorrichtung, dadurch gekennzeichnet, daß man auf einem Substrat (11) durch selektives Ätzen unter Verwendung eines Maskenmusters (22) ein Projektionsmuster (12) erzeugt, auf dem Projektionsmuster (12) derart eine Polymerisathharzschicht (13) ausbildet, daß diese in der dem Substrat abgewandten Oberfläche geringe Ausbuchtungen und Vertiefungen aufweist, wobei die Ausbuchtungen und Vertiefungen ein schwach gekrümmtes Profil aufweisen und mit dem Projektionsmuster (12) übereinstimmen, und auf der Polymerisatharzschicht (13) derart einen reflektierenden Metallfilm (14) erzeugt, daß dieser in seiner Außenfläche kleine Ausbuchtungen und Vertiefungen mit jeweils schwach gekrümmtem Profil, die mit dem Oberflächenprofil der Polymerisatharzschicht (13) übereinstimmen, aufweist, um einen reflektierenden Teil der Reflexions-Flüssigkristallanzeigevorrichtung herzustellen.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Polymerisatharzschicht (13) aus einem wärmehärtbaren Harz besteht.

3. Verfahren nach Anspruch 2, dadurch gekennzeichnet, daß das wärmehärtbare Harz aus einem Polyimidharz besteht.

4. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die Polymerisatharzschicht (13) aus einem thermoplastischen Harz besteht.

5. Verfahren nach Anspruch 4, dadurch gekennzeichnet, daß das thermoplastische Harz aus einem Silikon- oder Fluorkohlenstoffharz besteht.

6. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß der reflektierende Metallfilm (14) aus Aluminium, einer Aluminiumlegierung oder Silber besteht.

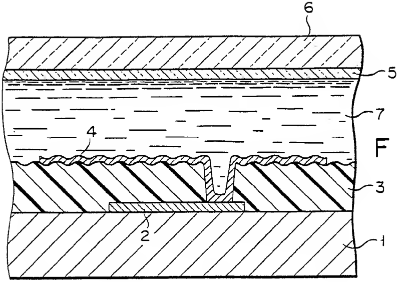
7. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß man auf einem Substrat (72) mit unebener Oberfläche eine ebene Schicht (71) erzeugt, auf der ebenen Schicht (71) das Projektionsmuster (12) ausbildet und die Ausbuchtungen und Vertiefungen in der Polymerisatharzschicht mit dem Projektionsmuster (12) in Übereinstimmung bringt.

8. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß der Flüssigkristall aus einem Flüssigkristall vom Typ Guest/Wirt besteht.

9. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß man so lange selektiv ätzt, bis die Oberfläche des Substrats (11) freigelegt ist.

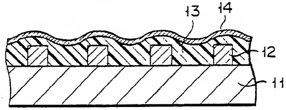
10. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß man die selektive Ätzung als reaktive Ionenätzung durchführt.

11. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß man die Polymerisatharzschicht (13) durch Spinnbeschichtung erzeugt.

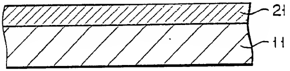


F I G. 1

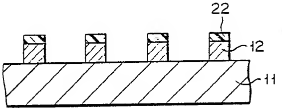
F I G. 2



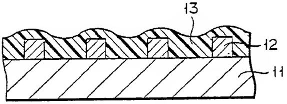
F I G. 3A



F I G. 3B



F I G. 3C



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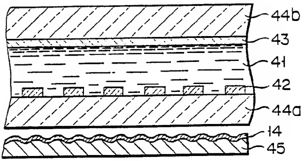

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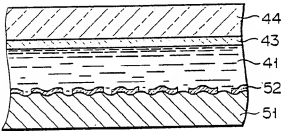
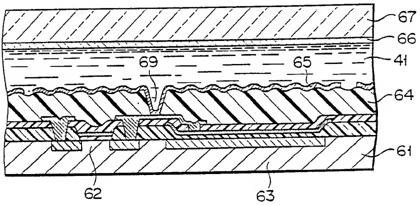
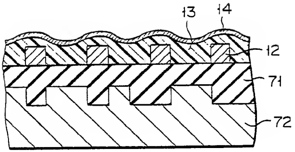


F I G. 6



F I G. 7A



F I G. 7B